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 L'Administration Imperial des Mines de Russie.
 La Société de Physique, &c. de Genève.
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The President (G. B. Airy, Esq. Astronomer Royal) then addressed the Meeting on the subject of the award of the Medal as follows:—

Before I proceed to my immediate object, you will allow me, gentlemen, to express my regret that the duty of addressing you should have fallen upon me. The place which I reluctantly oc-

cupy ought, in the ordinary course, to have been filled this day by one to whom this Society mainly owes its existence and prosperity, and with whose scientific life every portion of our history is indissolubly interwoven. I will not, however, enlarge further on this irretrievable loss, but will briefly remind you that every member of the Society, who has been proud of his connexion with it while its interests were successfully supported by Mr. Baily, is bound in honour and conscience to give his best efforts for its continued prosperity, by the means which have hitherto proved so successful: individual and independent efforts tempered by a love of unanimity, and zealous industry guided by prudent forethought.

It is the duty of your president, gentlemen, to announce the decision of the Council as to the award of the Medal which, by the laws of the Society, is at their disposal on the present occasion: and I have to inform you that the Council have awarded the Medal to Captain W. H. Smyth, R.N. Foreign Secretary of this Society, for his *Bedford Catalogue*, forming the second part of the work entitled *Celestial Cycle*, which has been published by that gentleman within a few months.

The *Bedford Catalogue* contains the most interesting double and multiple stars of which the primaries are in Piazzi's Catalogue, and a selection of clusters and nebulae from Messier's Catalogue (*Conn. des Temps*, 1784) and from the papers of the two Herschels; comprising 170 nebulae and clusters, 580 double stars, 20 binary systems, and 80 triple and multiple stars. The magnitude, colours, &c. of the stars are carefully noted; there are numerous comparisons with the results (published and unpublished) of other observers; and the proper motion of the primary of each system is given with care. This scientific information is accompanied with much antiquarian research and literary history, and the work is likely to prove extremely attractive to the general reader. But the value of the work, in reference to the Medal of this Society, is derived almost entirely from its measures of double and multiple stars, and to these I shall confine my further remarks.

The subject of the labours for which this Medal is awarded is interesting; and the circumstances under which the Medal is awarded are peculiar. It is incumbent on me to make a few remarks upon the subject, and to explain the circumstances to which I allude; but, after the Report which has so long engaged your attention, it is necessary for me to be brief.

The astronomy of double stars may be stated to have commenced with Mr. W. Herschel's paper in the *Philosophical Transactions*, 1782. It is, therefore, essentially a modern science. But it is worth while to remark that it was not then begun with the views which have since become the principal motives for pursuing it. It was begun with the intention of discovering whether the observations of stars presumed to be at very different distances, but nearly in the same position as seen from the earth, would exhibit any indication of the earth's annual parallax. No such indication was discovered; but an unexpected and perhaps a more important

result was in no long time deduced from the observations. The relative places of the components of a double star were found to change, and the change had no respect to the position of the earth in its orbit, but went on from year to year. In several instances the change altered its character so completely that it could be represented in no way but by supposing that one star revolves round the other. And from that time the observations have been pursued almost exclusively with the view of tracing the orbits of binary stars.

One step of great importance has been made. Methods have been successfully introduced for the investigation of the elements of the orbits of double stars, on the supposition that the law of gravitation applies to them. And these methods have been applied to many stars, and from the elements so computed ephemerides have been prepared, by means of which the theoretical position of the double stars, computed on the same law of gravitation, may be compared with the position which shall be observed in the heavens.

To complete this outline of the progress of double-star astronomy, it appears only necessary to add, that it is believed that not more than one or two stars have completed their revolutions since they were first observed, and that there is no sufficient evidence that the same orbit has been retraced in successive revolutions.

Had I attempted, gentlemen, to enter more in detail into the history of this science, I should have done little more than weary you with the repetition of the same name. A Herschel was the projector of the science; the same Herschel established it to the utmost extent to which a most powerful intellect using the most powerful instruments in the world could carry it; another Herschel improved the accuracy of the observations, increased their number, and fixed the positions of many stars for an epoch sufficiently distant from the former to give accurate measures of their motions; and, finally, introduced that method of determining the elements of their orbits which is yet probably the best that exists. A Struve has filled volumes with the records of the observations made with the magnificent instruments at his command. Compared with these, the additions made by others to the theory or to the observations appear small. Yet it would be unjust to omit mention of the labours of Savary on the theory, and of those of South, Dawes, Bessel, and Mädler on the observations. To these names we can now add that of one whose labours place him in a higher position, the name of Smyth.

I may perhaps, for a moment quit the scientific part of this notice to remark that this science is in its origin and principal advances essentially English, and that by far the greater part of the work done upon it has been done by private and not by official observers. The former class is one of whom our country has good reason to be proud. I say advisedly that, since the time of Tycho, no country has witnessed efforts, directed with such force, such judgment, and such perseverance, as those of Herschel and Groombridge in sidereal observation, and those of Baily in

astronomical literature and in observations of a different class. It has been the pride of our men of business to shew that in them at least the effect of the cares incidental to their position has been not to degrade but to sharpen the intellect; not to render it insensible to every thing but gain, but to shew that honourable gain is only a means to an end, and that that end is the very highest cultivation of the mind.

Although the instance before us is in some degree different, its general character is the same. An officer, whose rank has been derived, in the first instance, from the honourable profession of arms; whose European reputation has been founded upon his services, first as a volunteer and afterwards in official employment, in the scientific and useful task of maritime survey; employs the leisure hours of his riper years upon the furtherance of the astronomy of double stars, devotes to that object his fortune and his energies with a perseverance scarcely inferior to those of the persons to whom I have already alluded, and finally produces an extensive catalogue of double stars possessing, as we believe, the highest claims to the favourable reception of the scientific world. I cannot forbear to add that the results of this labour have been published in a form which cannot fail to fix the attention and to direct the studies of many other able men of the same class: but I add also that this circumstance ought to have no influence, and has had no influence, in deciding your Council on the award of this Medal.

I might offer you my reasons, gentlemen, for believing that observations, like those of double stars, requiring little calculation, but demanding peremptorily the most complete devotion of time and energies when favourable states of the air occur, are likely always to be better carried on by private observers than by official astronomers. I might state, that the regular observer, when wearied with five hours' calculation in the forenoon, is not likely to seize upon that precious sky which sometimes suddenly presents itself in the evening, and to continue his observations till dawning day terminates them. I might, on the other hand, explain that private observers can seldom undertake the masses of calculation which are incidental to meridional observations. But I shall remark no further on this than to observe that, in the instance of the double-star observations before us, as well as in many of the others, discretion has been shewn in the selection of the subject as well as perseverance and skill in the pursuit of it.

Gentlemen, the position of the person by whom this work has been executed is thus far important, that it is necessary for us to distinguish between the work executed in the discharge of official duty, and that which is presented by the gratuitous labour and expense of a private individual upon whom we have no claim of any kind. The former circumstance may frequently prevent us from even taking into consideration the merits of some important works: the latter will render similar works admissible for our judgment as to the propriety of awarding to them our medal. But

when I have said *admissible* for our judgment, I have said all. No claim whatever is established by this gratuitous character of the work. The claim must be founded only upon the value of the work with reference to the present wants of science: and to this point I shall now advert.

It has happened, gentlemen, that I have twice had the honour to deliver addresses from this chair, in which allusion has necessarily been made to the nature of the nebulae, and of those apparently nebulous bodies, the comets. I have endeavoured to explain my idea, that it is in the examination of these that the cosmogonic mysteries of the world are to be read on the large scale, as in geology on the small scale. The investigation of the motion of double stars appears to me likely to give us an insight into laws equally grand, but of very different character. It is here alone that we can see the mechanics of the universe on a grand scale. The radius of the orbit of *Uranus* is small in comparison with the distance of the two stars of 61 *Cygni*, and probably *very* small in comparison with the distance between the components of some binary stars whose parallaxes have not yet been ascertained. The law of gravitation seems to be failing even at the distance of *Uranus*. May it not, perhaps, fail more completely, or may not a different law almost completely prevail over it, at distances like those of the double stars? Whether this question is to be answered affirmatively or negatively, and whatever may be the modification which the law may require, this appears certain, that it is only in the observation of double stars that we can find an answer to the question.

If now we inquire what is the quality of our observations upon which the correctness of our answer will mainly depend, we find that it is *accuracy*; comprising under this word the two different steps, of exactness in making observations, and certainty in transmitting them to the reader. And upon the importance of this accuracy, as contrasted with number or variety, I cannot express my opinion with sufficient strength. It is matter of history that the establishment of the laws of Kepler, of the system of Copernicus, and finally, of the theory of gravitation, depended upon a discordance between the theory of that period and the observations amounting to eight minutes of arc. This was then a small quantity but certainly appreciable, if the best instruments and best methods of the time were used. Now, gentlemen, am I wrong in saying that the establishment of a cosmical theory, infinitely more comprehensive and more important than that of gravitation, may depend upon the certainty of a measure to the tenth part of a second? I say, that it is more than possible; that it is highly probable; and that there is fair probability of its occurring within our time. Kepler on a similar occasion put to himself the question, "Is it likely that an observer so accurate as Tycho can have been in error by eight minutes?" and boldly answered to himself, "It is impossible, and, therefore, a new theory must be formed." When the question shall be put regarding the measures of the Bedford

Catalogue, made at a critical time, and on which a future theory may hinge, Can these numbers be trusted with certainty to one or two-tenths of a second? shall we be able to answer, Without doubt they can? This leads me to a very important part of my present remarks.

The Catalogue of the Celestial Cycle, as exhibited to the public, contains simply the result for each star of all the observations made on that star. In some cases results are given for more than one epoch: but, in all cases, every result is given without exhibition of the individual observations from which it was deduced. This form of publication is open to a very grave objection, and one which was seriously discussed by your Council. In a remark above I spoke of the accuracy of published observations as depending on two circumstances: exactness in making the observations, and certainty in transmitting them to the reader. With regard to the exactness of the observations, we had the evidence of a member of the Council who had compared unpublished observations made under the most unquestionably favourable circumstances with individual observations made by Captain Smyth: and we had also the indirect evidence derived from the progressive changes in the relative positions of some of the stars. These kinds of evidence probably had their weight with members of the Council; but to me, I must aver, they were entirely unnecessary. My confidence in the exactness of the observations is purely personal. Knowing the attention which has been given to the adjustments, the intentness of the observer upon his work, the nerve which is made steady rather than disturbed by the anxiety to procure a good observation, and the general skill in the management of the instruments, I can truly say, that if an accurate observation were required, I would desire that it should be made by Captain Smyth. Yet I could wish that I had the means of exhibiting to the world the grounds of my general confidence in the skill of the observer. Still more, I wish that I could produce sufficient means for estimating numerically the probable error of the observations, as affected not only by personal sources of error, but also by the causes of error which no skill can overcome. These remarks apply to the probable exactness of the observation only. With regard to the certainty of transmission to the reader, there is no sufficient security. The fairness of apportionment of weights, the correctness of means of separate results, the correctness of the printing; for all these there is no security. Let it not be supposed that these remarks are answered by referring me to the circumstances, that the computation is easy, that it has been performed by the astronomer himself or immediately under his eye, and that he has himself superintended the printing. I know by experience that errors are more likely to occur in easy than in difficult computation: that the principal person usually performs calculations and reads proof sheets with less accuracy than comparatively illiterate assistants; and that, after all his care in passing the sheets through the press, errors will creep in over which he has no control whatever. Had the manuscripts of the

observations and of the calculations in this instance been placed at our command, my remarks would have been completely answered. In the case of Lord Wrottesley's Catalogue, to which the Medal of this Society was awarded, and in that of Groombridge's Catalogue, the printing of which was placed by the Admiralty under my superintendence, the original observations and the intermediate calculations were placed at the command of this Society; and the repeated references which already it has been found necessary to make to the latter manuscripts prove the propriety of this caution. In the instance of the Bedford Catalogue we have no such power of referring to the originals. Feeling these things, gentlemen, and impressed with a sense of the responsibility to you and to the world of science which is implied by my position in this chair, I deem it my duty to state to you, that I for one have hesitated in assenting to this award except in the hope that the manuscripts relating to these observations would at some time be placed in our hands. And I am fully persuaded that it is the general feeling of the Council that the reasons upon which this Medal is now presented are such as have never before been used to justify our awards, and are not likely to be used again. I trust that the value of the Medal will be greatly enhanced to Captain Smyth by this consideration. I trust that he will perceive that, where direct evidence was wanting, this Council have not refused to give to the world their most solemn assurance of the value of the Bedford Catalogue, relying only, until further security shall be given to them, upon their personal appreciation of the instrumental skill, the editorial care, and the general exactness and fidelity of the observer.

(The President then, delivering the Medal to Captain Smyth, addressed him in the following terms):—

Captain Smyth,—In the name of the Council of the Royal Astronomical Society, I present to you this Medal. And I beg leave to convey with it the expression of my own opinion that never was a Medal more worthily earned. Permit me, sir, at the same time to remark, that the character of the Council is most deeply pledged in this award, and that I trust that, at no distant period, it will be redeemed by such communication of the details of the observations as will enable the Council to refer other inquirers to publications that are within the reach of all for a sufficient justification of this judgment.

The Meeting then proceeded to the Election of the Council for the ensuing Year, when the following Fellows were elected, viz.

President: Captain W. H. Smyth, R.N. K.S.F. D.C.L. F.R.S.
—Vice-Presidents: George Biddell Airy, Esq. M.A. F.R.S. Astronomer Royal; Samuel H. Christie, Esq. M.A. F.R.S.; Bryan Donkin, Esq. F.R.S.; Thomas Galloway, Esq. M.A. F.R.S.—
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